In Searching of Innovations

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Humanity has chosen the path of progress hundreds of thousands years ago. In the beginning it strode rather slowly; fire, wheel, tools – these inventions did not come easily. In the course of time, man becomes more and more innovative. Nowadays, humanity runs the path of advancement with the speed of sound and does not seem to be slowing down. Today almost at every step we are attacked with news about discoveries, inventions aiming to change the everyday life. Some of them, like for example contact lenses, make life more comfortable; other – like self-cleaning surfaces and make the everyday duties easier, while OLED displays provide entertainment. The histories of such inventions are much older than we expect, as well as much more interesting.

Perfect sight without glasses

The history of contact lenses began in renaissance [1,2]. In the beginning of XVI century the greatest Italian polymath, Leonardo da Vinci, came up with an idea to correct the visual impairments with the use of lenses placed directly on the cornea [3].

Fig. 1. Leonardo da Vinci (Source: Wikipedia)

Unfortunately, this innovative idea was impossible to implement because of the lack of proper materials. Leonardo's concept was being analyzed by scientists for several centuries. Rene Descartes (XVII c.) and Thomas Young (XIX c.) both found this idea a promising one, however, they did not succeed to put it into practice.

In 1823 an English astronomer, chemist and physicist, John Herschel, decided to consider it once again and proposed to use some transparent animal jelly contained in a capsule of glass. It is not known whether Herschel decided to bring his invention into effect.

In the late 1880s, three scientists: Swiss ophthalmologist Adolph Eugene Fick, French ophthalmologist Eugene Kalt and German medical student August Müller, produced glass contact lenses, independently. The first lenses were different from these we use nowadays. In fact, they were made of blown glass bubbles and covered almost whole surface of the cornea. Not only were they heavy but also oxygen impermeable, what resulted in a low tolerance while wearing. Moreover, patients usually suffered from signs and symptoms of corneal hypoxia.

Between 1890 and 1935, two German companies produced contact lenses, however, the demand was rather low. According to the American Academy of Optometry, between 1935 and 1939 only 10 000 pairs of contact lenses were sold in the U.S. [4].

William Feinbloom was a first researcher who decided to replace glass with plastics. The new generation of contact lenses was made of opaque resin (1936). It took only two years to make a huge progress and start using poly(methyl methacrylate). Plastic contact lenses were much lighter, easier to be formed and shaped, biocompatible, so wearing them was much more comfortable. Nevertheless, they still had some drawbacks. Contact lenses made of PMMA, usually called "hard" contact lenses, could easily dislocate, resulting in a discomfort. What is more, also in this case, the main problem was associated with the low oxygen permeability. However, patients seemed to be satisfied and the contact lenses sales increased from 50 000 pairs in 1946 to 200 000 pairs in 1949 [4].

The next breakthrough took place in 1954: the chemists from Czechoslovakia, Otto Wichterle and Drahoslav Lim, synthesized first hydrogel – (hydroxyethyl)methacrylate,

HEMA. The "soft" contact lenses made from polymerized HEMA (PHEMA) apparently hit the jackpot! This polymer not only is a transparent material, free of impurities but also permeable for oxygen and water-soluble nutrients. From that time, in a production of contact lenses, the following hydrogels are used: poly(2-hydroxyethyl methacrylate), copolymers based on poly(1-glycerol methacrylate), as well as copolymers based on tris(trimethylsiloxy)silylprophyl methacrylate [5].

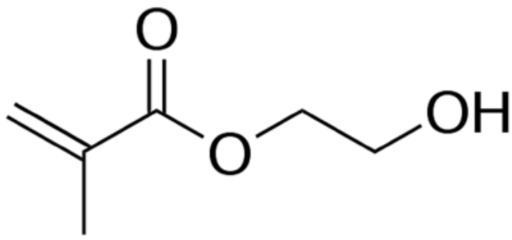

Fig. 2. HEMA - (hydroxyethyl)methacrylate

Contact lenses become comfortable, safe and inexpensive. Nowadays, they are used by approximately 125 million patients all over the world [6]. Also their functionality increased drastically. Soft contact lenses are utilized for the correction of visual impairments, such as: myopia, hyperopia, astigmatism and presbiopia. What is more, they can be used for other therapeutic purposes [7,8]. A good example may be a "bandage" lenses that protects an injured cornea from rubbing of blinking eyelids, in this way allowing it to heal.

Contact lenses may be applied in the treatment of dry eye, corneal abrasion, erosion and keratitis. With the aid of plastic lenses it is also possible to control the drug delivery.

Always-clean surfaces

For the east cultures lotus is a symbol of purity. Although it grows in muddy lakes and rivers, it does not become dirty. No earlier than in 1997 two German biologists, Wilhelm Barthlott and Christoph Neinhuis, revealed the lotus' secret [9]. The surface of this plant is covered with small waxy bumps, responsible for the super-hydrophobic properties of the surface. Raindrops falling on the surface of lotus leaves do not wet the surface and remain their spherical shape. When leaf moves, for example from the wind, raindrops roll down and pickle up dirt particles. Since 1997 this phenomenon has been known as „the lotus effect", even though the self-cleaning properties are also exhibited by the leaves of cabbage, Indian cress and gorse, as well as the surface of butterflies' wings [10].

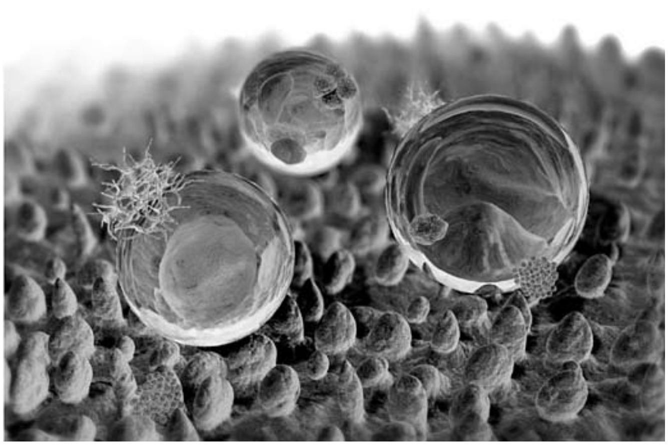

Fig. 3. A surface of lotus leaf (Source: Wikipedia)

Before „the lotus effect" was investigated, scientists suspected that the surface of certain morphology may exhibit super-hydrophobic properties. A.B.D. Cassie, S. Baxter and Robert N. Wenzel were pioneers in this area of research – in 1940s they modified Thomas Young law (XIX c.), describing the equilibrium shape of a drop on the surface [11,12]. What they added was a crucial factor – surface morphology, its porosity and roughness. It was a beginning of a new direction of research; hydrophobicity turned out to be the property influenced not only by the choice of a surface material but mainly by its morphology.

For the first time, a synthetic surface demonstrating super-hydrophobic properties was described in 1996 by a group of scientists working for Kao Corporation [9,13]. It was produced by treating an anodically oxidized aluminum surface with a fluorosilane. Since then, an explosion of interest in such type of surfaces could have been observed. During just 15 years, the numerous articles demonstrating a synthetic route of new super-hydrophobic materials have been published. The most often mentioned were: fluorocarbons (e.g. a double-roughened perfluorooctanesulfonate doped conducting polypyrrole – first super-hydrophobic conductive polymer able to be switched between super-hydrophobicity and superhydrophilicity [14]) and silicones (e.g. polydimethylsiloxane – super-hydrophobic is achieved after nano-casting a structure of a lotus leaf [15]). The other materials, able to be successfully modified are: polyethylene, polystyrene, polyamide, polycarbonate, alkylketene dimmer, as well as zinc oxide and titanium(IV) oxide [10]. The desired surface morphology may be obtained with the use of etching (plasma, etching, laser etching and chemical etching), lithography (photolithography, electron beam lithography), sol-gel processing, electrochemical deposition and chemical or physical vapor deposition [10].

There is a wide range of potential applications of super-hydrophobic substances. First commercial product that appeared on the market (1999) was Lotusan – silicon elevation paint having self-cleaning properties [16]. Since then, numerous products using „the lotus effect" have been introduced: lacquers for vehicles, waterproofing of clothes and self-cleaning windows in skyscrapers. Super-hydrophobic surfaces might be used in the fabrication of DNA microarrays to control the flow of droplets and avoid contamination [17]. Nowadays, there are some researches, conducted to create artificial leaves able to generate hydrogen in a process similar to photosynthesis [18].

The screens of the future

The phenomenon of electroluminescence (an emission of light from a substance after application of voltage or placing it in an electric field) was observed for the first time in 1907 when English scientist Henry Round was passing a current through a silicon carbide detector [19]. However, the word "electroluminescence" for the first time was used in 1936 by French scientist Georges Destriau, who made zinc sulfate emit light. Nevertheless, form a point of view of people living in an era of mobile phones, digital cameras and portable music players, the most significant was a discovery made by Martin Pope, who in 1963 described the electroluminescence of organic semiconductors [20]. However, this breakthrough seemed not to be of a practical use because of the high voltage needed. The about-turn occurred in 1987 when Ching W. Tang and Steven Van Slyke, scientists working for Kodak company, showed first organic light-emitting diode (OLED). This device was composed of an emissive layer (8-hydroxyquinoline aluminum), a hole-transporting layer (aromatic diamine), substrate, cathode (magnesium-silver alloy) and anode (ITO – indium tin oxide) [21]. During operation, a voltage was applied to a diode, layers became charged, electrons and holes recombined with one another and light was emitted. OLED did not require application of a high voltage and were very efficient.

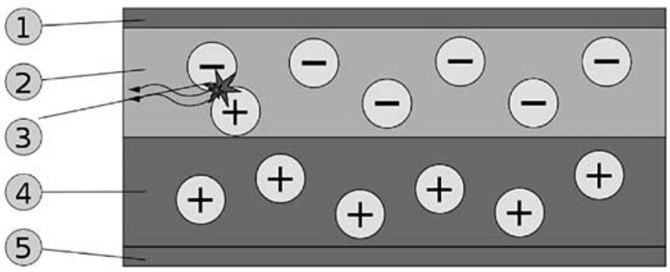

Fig. 4. Schematic of a bilayer OLED:
1. Cathode (−), 2. Emissive Layer, 3. Emission of radiation, 4. Conductive Layer, 5. Anode (+) (Source: Wikipedia)

Just 3 years later, Richard Friend, Jeremy Burroughes and Donald Bradley, scientists from the University of Cambridge, described first polymeric light-emitting diode (PLED), for a production of which they applied polyphenylene vinylene.

OLED technology is now a multi-billion dollar business [20]. The displays of almost all small digital devices such as: mobile phones, digital cameras and watches are made of organic light-emitting diodes. What OLED can offer us? Is it really better than LCD? First of all, OLED displays do not require an additional backlight, hence they may be thinner and lighter than LCD. What is more, organic displays consume from 20% to 80% less energy than liquid crystal ones. OLEDs provide better contrast, brighter colors and a wider viewing angle. Moreover, electroluminescent organic diodes can be deposited on different types of surfaces, both elastic and rigid, what gives a variety of new applications. However, OLEDs are not drawback free. The worst one is the limited operational time [22]. Continuous operation of OLED causes a steady loss of its efficiency and a gradual rise in a bias voltage.

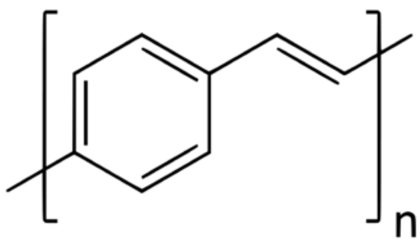

Fig. 5. Polyphenylene vinylene

How the screens of future will look like? It is highly probable that they will be just an improved OLED or PLED displays. There are still some challenges: extension of an operational lifetime, development of a better production technology and lowering the cost of fabrication are only a few mentioned [23]. The modification of an emissive layer may also lead to a success.

It may be concluded that the main inspiration for many scientists is nature and the main intention – make life more comfortable. With the continuous development of science, the old ideas become possible to implement. What used to be just a conception, nowadays can be easily put into practice.

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Translation into English by the Author

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The Role of Chemists in the Discovery of New Medicines

Oct 13, 2011, Lecture Theatre X1, School of Chemistry,

University of Nottingham, University Park,

Nottingham, NG7 2RD, UK

This lecture aims to illustrate how the field of medicinal chemistry has led and will continue to lead to the discovery of new medicines which impact millions of lives worldwide. Using specific examples, a description will be given of the processes involved in taking the knowledge of a of modern day disease mechanism (such as cancer, AIDS etc.), and applying problem-solving techniques to design molecules to interact with specific biological targets, thereby saving lives and improving the quality of life. This talk will highlight how diverse technologies (such as robotics used originally in the car industry and supercomputers) and ground-breaking discoveries in other scientific fields (biology, analytics, formulation, large-scale chemistry, engineering) are co-ordinated in the design of new therapeutic agents, with the emphasis being on how chemistry is the core science which makes this possible.

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